REPLY COMMENT

By GREENWOOD TELECOMMUNICATIONS CONSULTANTS LLC DENVER, CO

Re: DA 13-1717, IB Docket Nos. 12-340, 11-109; IBFS File Nos. SAT-MOD 20120928-00160, -00161; SAT-MOD-20101118-00239; SES-MOD-20121001-00872; RM-11681; WT Docket No. 12-327

Introduction

In this proceeding the Commission has asked respondents to comment on analysis[1] of out of band emissions (OOBE) and outcomes or conclusions pursuant to mitigating OOBE to affected receivers following an ex parte presentation made by LightSquared LLC[2]. This Reply Comment primarily addresses certain comments made by the GPS Innovation Association ("GPSIA") in their critique of the July 15, 2013 LightSquared produced OOBE analysis and presented in an Ex Parte, the subject of this proceeding, plus offers related recommendations intended to move the issue toward resolution.

While our comment[3] analyzed and concludes that it is optimal to reach a commercially feasible level of OOBE upgraded to -105dBW/MHz from mobile and station equipment to limit those emissions into the various GNSS bands to protect GPS operations, we find a particular point made in the GPSIA Comment[4] wanting regarding their claim that the LightSquared analysis offered in their ex parte[5] failed to address inter-system compatibility by not including impact of Adjacent Band Interference (ABI), or "overload"[6].

We believe the GPSIA's assertion made in their comment fails to capture the proper crowded-spectrum context in which GNSS receivers also must closely co-exist with terrestrial communication devices and it ignores the primary role of resolving adjacent band interference at the point of interference impact, inside the affected GNSS receivers. This point first assumes the adjacent band transmitters operate within lawful radiated power and site deployment limits. It also assumes that the frequency difference between down and uplink equipment and the GNSS bands are separate enough to practically reject using appropriate filtering. Based on our analysis plus limited testing of civilian GNSS receivers, we

[1] Public Notice August 7, 2013, Wireless Telecommunications Bureau, Comments Sought on LightSquared Subsidiary LLC Ex Parte Filing IB Docket Nos. 12-340, 11-109; IBFS File Nos. SAT-MOD-20120928-00160,-00161; SAT-MOD-20101118-00239; SES-MOD-20121001-00872; RM-11681; WT Docket No. 12-327 Report No. SPB-253 "We seek comment on the [LightSquared LLC] *July 15, 2013 Presentation*, including its analyses, assessments, and its conclusions", link: http://apps.fcc.gov/ecfs/document/view?id=7520936682

[2] LightSquared LLC Notice of *Ex Parte* Presentation*; IB Docket No. 11-109; DA 12-1863, IB Docket No. 12-340; IBFS File Nos. SATMOD-20101118-00239; SAT-MOD-20120928-00160; SAT-MOD-20120928-00161; SES-MOD-20121001-00872; RM-11681; WT Docket No. 12-327*, July 15, 2013, link: http://apps.fcc.gov/ecfs/document/view?id=7520930804

[3] Comment re: DA 13-1717, IB Docket Nos. 12-340, 11-109; IBFS File Nos. SAT-MOD 20120928-00160, -00161; SAT-MOD-20101118-00239; SES-MOD-20121001-00872; RM-11681; WT Docket No. 12-327 Greenwood Telecommunications Consultants LLC FCC, On the Matter of Out of Band Emissions (OOBE) Interference in GNSS Bands, September 6, 2013, link: http://apps.fcc.gov/ecfs/document/view?id=7520942521

[4] COMMENTS OF THE GPS INNOVATION ALLIANCE, IB Docket No. 12-340 and other, September 6, 2013, link: http://apps.fcc.gov/ecfs/document/view?id=7520942602

[5] Op Cit. LightSquared LLC Ex Parte

[6] Op Cit. GPS Innovation Alliance, p. 10

conclude 1.5kW EIRP base station downlinks above 1670MHz are safe to operate without causing harmful adjacent band interference to GNSS receivers. There is nothing in the LightSquared Ex Parte OOBE analysis to indicate it would intend to operate outside its authorized power limits, indeed based on the current record it is logical to conclude it would use should it emerge alternative spectrum vastly different in interference potential than observed in its earlier proposals from 2010-11.

Mathematically aggregating adjacent band with OOBE interference or not, we conclude that the responsibility to reduce interference is jointly held: OOBE compliance mostly resides with suppliers of devices with transmitters while responsibility for mitigating adjacent band interference mostly resides with the receiver suppliers. Therefore, true mitigation requires the "un-coupled" stakeholders work jointly to define compatible standards, and suitable transition time of future equipment which should optimize use of the scarce spectrum.

Overload Interference Properly Analyzed is Independent of OOBE

The GPSIA Comments criticizes the LightSquared OOBE analysis for failing to account for what the GPSIA contends as additive "overload" interference based on their proposed uplink and downlink transmissions. An excerpt of one of several times this issue was mentioned appears below:

> *"*Second, the *Ex Parte* fails to consider the aggregate effects of LightSquared's operations – whether base station or handsets – on GPS operations. For instance, as the Federal Aviation Administration ("FAA") noted in a January 2012 report, *an interference analysis of the impact on aviation devices from LightSquared's proposed network must consider the aggregate effects of both overload and out-of-band emissions ("OOBE") from all of LightSquared's planned operations in the uplink and downlink bands*.[22/] Although LightSquared relies on independent Minimum Operational Performance Standard limits for OOBE and overload to aviation devices, *it never considers the aggregate effects across all of its operations*.[23/] For GLN devices, LightSquared similarly analyzes overload and OOBE independently for a single handset band;[24/] *if it had combined them, its analysis would have shown harmful interference.*[25/] *Further, for high precision devices, LightSquared analyzes OOBE and overload independently, but never considers the aggregate case*."
> [Italics added for emphasis]

In our view their critique has two flaws. The first is context – as indicated above the setting in which the LightSquared OOBE analysis and proposal assumes a GPS-compatible downlink transmission regime. It is well documented that LightSquared seeks to operate downlinks (and thus requests authority) by unifying with a band between 1670-75MHz and a portion of an under-utilized NOAA meteorological aids band between 1675-1680MHz to aggregate into a single downlink LTE channel. This significant change is a result of modifying their plan to avoid interference with GPS/GNSS operations. The Commission recently granted LightSquared temporary authority to conduct tests in that band, which is at the least a showing of feasible compatibility with NOAA and presumably GPS spectrum based services. Operation within the NOAA band was not tested in either the TWG 2011 or subsequent WSMR/NTIA tests frequently referenced in the GPSIA comment. Thus the 2011 test results referenced by GPSIA Comments have little if any relevance to the current OOBE proceeding sought by the Commission.

Also in terms of context and consistency, there is no account in the GPSIA critique of the Ex Parte submission why LightSquared mobile devices and transmissions, shown to be well below prevailing MSS uplink EIRP levels which operate in the same (and closer) uplink bands, should be treated differently than legacy MSS devices. LightSquared proposes reduced OOBE level and though it's not to extent this we recommended in our Comment, it's at least a measure of progress relative to today's management of OOBE and ABI in the L Band. Afforded an OOBE limit by current rules generally -70 dBW/MHz, MSS today has 35dB greater OOBE power than what is required to maintain crowded-spectrum compatibility. Apparently forgotten here is the fact that MSS devices with lax OOBE (even if not aggregated with ABI) could upset GPS receivers tens of meters away or more for those devices.

Second and more important to crowded-spectrum policy decision making, resolution of adjacent band operations is, necessarily and indefinitely, a shared and coordinated responsibility among spectrum stakeholders. Improving one mode of interference without improving the other results in virtually no gain thus is futile. Thus we contend -- as we interpret their analysis -- that the GPSIA recommendation to combine interferences would improperly burden only the wireless operators with the task of raising spectrum utilization which undermines attaining a joint OOBE/ABI resolution compatible with all L Band services.

Both forms of interference can and often will originate from the same source, and it is narrowly correct as GPSIA claims that the two forms manifest into a combined and undifferentiated noise product in the receiver. However, that conclusion detracts from the core issue of compatible operations between GPS and L Band terrestrial communications systems. In a crowded-spectrum regime, the rules should be organized to reach the best (safest and most economic) resolution paths to mitigate cross-band interferences where each form of interference requires pursuit forcing distinct mitigation approach in both receivers and transmitters. For example in communications systems standards, the 3GPP has organized interference performance standards by defining interference mitigation created independently in both the adjacently operating receiver and transmitter along with performance parameters (ACP, ACS) or specifications to coordinate system compatibility between the radio elements. That approach probably cannot be precisely copied but in principle provides an initial model to shape balanced interference mitigation performance for both terrestrial transmitters and the GNSS receivers.

Here as in some other spectrum management cases, the receivers and transmitters are "uncoupled" which makes productive coordination difficult without a sound multi-stakeholder resolution process. It is further worth noting that consistent with the GPSIA's previous statements, GPS/GNSS does have exceptional radio interference requirements due to its radio link constraints relative to most terrestrial communication systems.

We agree with the GPSIA that adjacent band interference or overload arises from signals that fall within the "overloaded" receiver's RF front-end bandwidth. It is important to note that harmful adjacent-band interference can also arise in a GNSS receiver without necessarily reaching levels that overload internal receiver stages, that is drive the receiver beyond the maximum linear operating point of its automatic gain control (AGC), a stage used to maintain faithful delivery of the analog signal into the first digital

conversion stage just after RF and down-conversion stages. Thus the term "overload" may be misleading or at best ambiguous to describe adjacent band interference. The receiver RF front end is typically designed to pass and amplify desired signals and reject all other undesired carrier frequency signals. If "overload" caused by relatively strong signals are present outside the desired band, then it brings into question (up to the point of commercial feasibility and appropriate emission rules) the receiver's adequacy of rejecting those increasingly common adjacent band signals.

If we are interpreting their comment correctly, the GPSIA apparently contends the entire responsibility for adjacent band interference should fall exclusively on to the terrestrial communication service operator(s) even where their' and others' terrestrial operations are within lawful EIRP limits. While the parties can honestly disagree with respect to LightSquared's OOBE analytical assumptions, test results or applicability, the concept of merging LightSquared's (or for that matter any of the other proximate wireless operations in the L Band) OOBE with its adjacent band interference as a matter of policy is improper, and if it were to govern, would result in an almost arbitrary spectrum management regime.

Allocation of Interference Mitigation and Rights Assignment Therein

Context is critical. If adjacent band transmitters operate within standard limits, we content that the adjacent band interference can only be practically mitigated by operating on the problem inside the receivers potentially affected.

Rational rights allocation and assignment are supposed to create a systematic expectation of quality service to the ultimate clients or customers of all radio based services, and this is becoming especially important to develop an increasingly crowded spectrum environment in as a productive and timely fashion as possible. Rational spectrum allocation in this case applies directly to the problem of balancing technical conditions for robust, highest-throughput communications -- while meeting conditions for hyper-sensitive radio navigation where both operate close together in the spectrum. In this case, excess transmission power in one service, terrestrial communications transmission, if not carefully balanced could severely constrain the quality-of-service for adjacent-band radio navigation operations. Similarly, an excessive reservation of unused ("quiet") terrestrial spectrum to serve a narrow interest (otherwise reasonably able to mitigate adjacent band interference effects) would result in wasted spectrum – an obviously precious resource. Regulation and rights assignment should therefore have the enforcement scope to reach both sides of the problem if efficient management of spectrum is a priority.

It is difficult to follow logic to set rules for a crowded-spectrum scenario that only address OOBE but are silent with regard to management of adjacent band interference. As the GPSIA comment points out both modes of interference can arise from the same signals and therefore from the same devices. Interestingly, certified GPS aviation receivers are carefully designed to resist adjacent band interference but due to lack of coordinated rules these same receivers are fully exposed to harm in part attributable to outdated, bluntly primitive OOBE regulations. On behalf of safety and convenience of the flying public, it makes sense to thoroughly protect aviation GPS receivers against OOBE, from one or any number of carry aboard wireless devices. To encourage this outcome, again rights assignment for

intentional radiating devices should reflect the duality of OOBE and adjacent band interference and the separate paths through which interference products potentially affect receivers. While at risk of sounding prescriptive or over-reaching in this reply, we recommend a rights regime support stringent OOBE protection in exchange for receiver suppliers agreeing to design adjacent band mitigation (with reasonable carrier frequency separations) equal to the task.

Finally, spectrum rights assignment should reflect both balance and medium or long-term transition from a relatively low to increasingly higher density use of L-Band spectrum. Further, shared responsibility and interference targets should be mandated that are informed by, or further evolved through a robust multi-stakeholder rule-recommendation process.

L-Band ATC and Shared Spectrum Operations are Still Novel, Thus Require Diligent Test Definition and Further Empirical Testing

Not only is there is a regulatory balance to be struck, L-Band ATC rulemaking should be based on continuing technical test processes including in-the-art simulations followed by reasonably rigorous and independent empirical tests to assure durable cross-band compatibility meet the intents of the rules (including OOBE and Adjacent Band Interference susceptibility).

In our view, the Commission would have greatly benefitted when it initiated ATC proceedings more than a decade ago by insisting then that the parties engage in a reasonable, rigorous test process similar to the 2011 TWG to at least confirm their that recommendations assure that all modes of interference and interaction were fully revealed and accounted. Such an undertaking could have been conducted by diverse but interested stakeholders similar to that conducted in the 2011 TWG process (which to its credit the Commission did authorize after the fact) before issuing rules regarding a then novel ATC dual-spectrum use regime in the MSS L-Band spectrum. Had these procedures been conducted prior to authorization, we believe it would have revealed the problems more recently seen, and would have positively informed the Commission regarding ATC operations, receiver-readiness, and could have started the march toward higher spectrum utilization back over a decade.

We also note that as evidenced by the years of consecutive L-Band ATC proceedings, there is an unprecedented degree of balancing to realize low interference ATC operations consistent with long transition lead-time or hyper-sensitive radio navigation legacy systems that a relatively small amount of L-Band spectrum is assigned to deliver. Therefore, to ensure certainty for their respective customers, all parties have an incentive to carefully balance OOBE and adjacent band interference with support from the Commission as an on-going process assuming ATC or other shared spectrum operations proceed.